Base Load Power Hub (BLPH)

Dropped Object and Swinging Loads Study

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1 INTRODUCTION

1.1 Project overview

Crosswind, a Shell and Eneco joint venture, was awarded the tender to develop the offshore Hollandse Kust Noord (HKN) wind farm, located 18.5km off the coast of Netherlands near the town of Egmond aan Zee. The consortium plans to have HKN operational in 2023 with an installed capacity of 759MW generating at least 3.3TWh per year. This is sufficient renewable power to supply more than 1 million Dutch households with green electricity.

Offshore wind farms produce intermittent electricity and balancing these dips and peaks and integrating this electricity into the national energy system requires new technologies. For this reason, the offshore wind farm will include several new technologies that could be implemented at full-scale in the future. The new technologies being explored include a floating solar park, a short-duration battery storage as well as long-term storage via green hydrogen produced by water electrolysis and subsequently consumed in a fuel cell. The combination of these individual measures, herein referred to as the Base Load Power Hub (BLPH) will ensure a continuous power supply regardless of the wind situation.

1.1.1 Project location

The Hollandse Kust Noord (HKN) wind farm is located 18.5km off the coast of the Netherlands near the town of Egmond aan Zee.

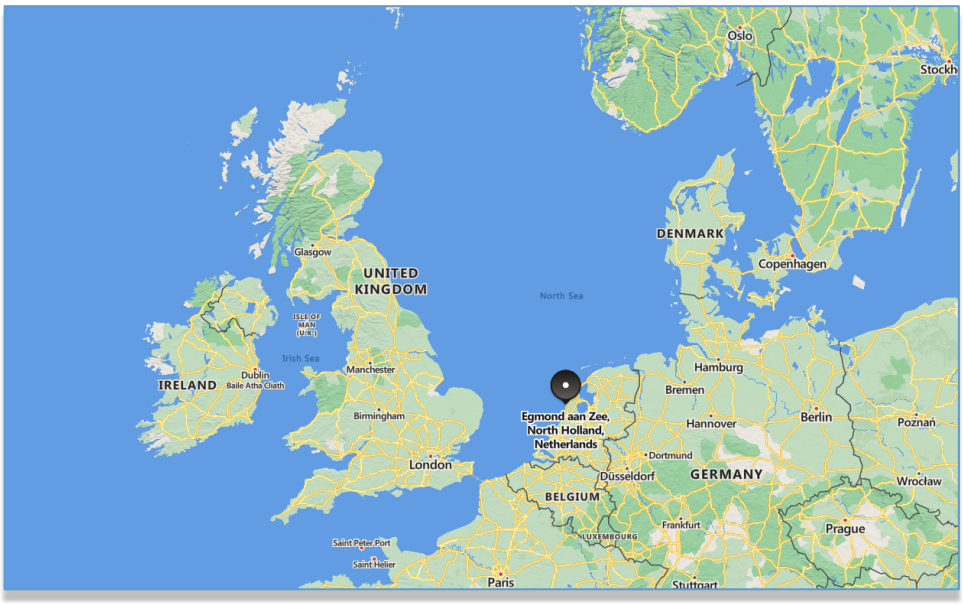


Figure 1 HOLLANDSE KUST NOORD WIND PARK Location Map

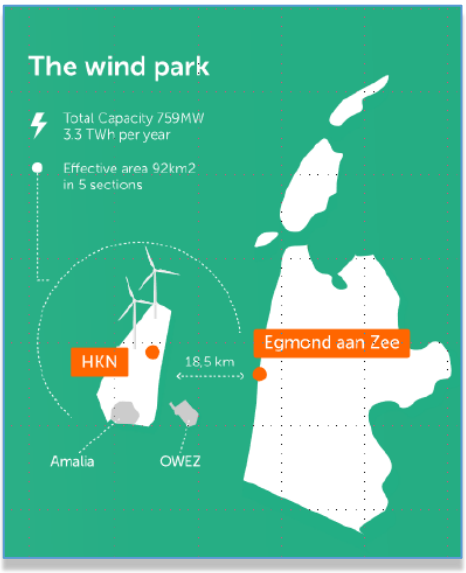


Figure 2 - Wind Park Details

The wind farm will consist of No. 69 x 11.5MW wind turbine generators each to be installed on a dedicated monopile structure. A 70th monopile located on coordinates E 590719.1, N 5841602.3 is reserved for installing the platform accommodating the BLPH. The monopile structure was designed and installed by Van Oord Offshore Wind (VooW) and therefore not part of the BLPH scope.

1.1.2 PROJECT CONCEPT

All components included in the BLPH will be integrated onshore on a topsides and installed in an offshore location within the boundaries of the HKN wind farm. At its simplest, the BLPH will store energy during periods of high electricity generation from renewable sources (a wind turbine generator and the floating solar PV farm) and release it during periods of low generation. In practice. It is expected that the energy stored will supplement generation from renewable sources to ensure that at least 1.0MW of power is exported to the electrical grid regardless of wind/solar availability.

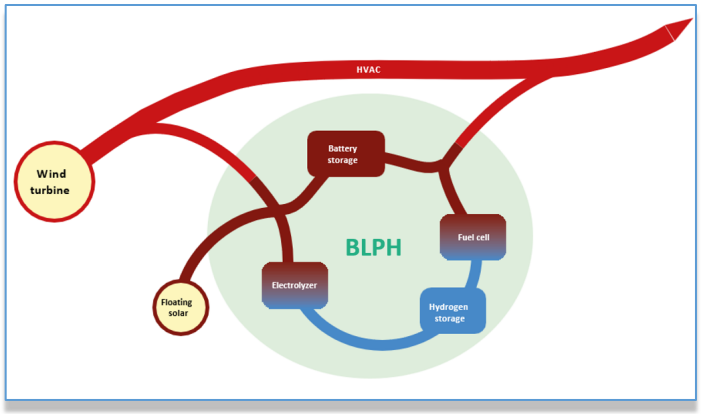


Figure 3 – BLPH Concept

Electricity in the BLPH will be stored in the form of electrons in a battery energy storage system (BESS) as well as converted into green hydrogen via water electrolysis. When the power output from the connecting wind turbine drops to below 1 MWe, the BLPH will return its stored energy to supplement the remaining power output. This will be by discharging the BESS, while stored hydrogen will be converted back into electricity using a fuel cell to extend the discharge duration.

The purpose of the BLPH s to function as a testbed for the integration of energy storage technologies with renewable generation. It is expected that equipment installed on the BLPH will operate as Normally Unmanned Installation for at least two (2) years with no or minimal maintenance and it will have its own independent control room with the ability to communicate with Crosswind's control room.

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2 DOCUMENT SCOPE

A dropped object is defined as an object that falls from a height and either causes or has the potential to cause an injury, asset damage or process safety event. This object can be of any size or mass, can fall from any height and may be dropped unintentionally or intentionally. Dropped objects have been identified as a potential hazard in a variety of offshore operational activities.

The aim of this document is to evaluate if a quantified dropped Object study is needed on the basis of expected consequences: if all identify dropping object will cannot lead to MAH, a quantified dropped Object study is not required. The main objective of this document is to verify if in case of dropped object from lifting due maintenance activities, a MAHs might be expected, according to HSE project design philosophy.

2.1 Main references

Ref.	Description
1	123A90-DDL-SAF-RE-30046 – HSE Design Philosophy, rev 01, 16/10/23
2	3D model of platform
3	123A90-DDL-PP-DL-70070 – Plot plan Lower & Upper deck, rev 02, 24/05/24
4	123A90-DDL-PP-DL-70071 – Plot Plan below lower deck, rev 02, 24/05/24
5	123A90-DDL-PP-DL-70072 – Plot Plan elevation looking north & east, rev 02, 24/05/24
6	123A90-DDL-ST-RE-90120 - Structural verification against accidental loads, rev.00, 19/04/2024
7	OOE-INN-FLS-DWG-00014 - Overview Location HKN1, rev D
8	123A90-DDL-SAF-RE-30009 - HAZID report, rev1

Table 1 - Reference Documents

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2.2 Definitions and abbreviations

2.2.1 Definitions

COMPANY or Client (CPY):	Crosswind
EPC CONTRACTOR (CTR):	ROSETTI MARINO S.p.A.
PROJECT:	HOLLANDSE KUST NOORD WIND PARK Project
Dropped loads	Refers to loads (objects) either unintentionally released from a lifting device or else swinging and impacting some part of the installation structure (or vessel, if the lift is to/from a vessel).
Lifting devices	It is referred to the crane located in the north side of platform.

Table 2 - Definitions

2.2.2 ABBREVIATIONS

BESS	Battery Energy Storage System
BLPH	Base Load Power Hub
HSE	Health Safety and Environment
HKN	Hollandse Kust Noord
MAH	Major Accident Hazard

Table 3 - Abbreviations

3 METHODOLOGY

The dropped object study represents an instrument to evaluate the risk due to an object dropping from the crane. The basic principle of present study is to verify that, after dropping, the expected consequences in terms of impact on:

- critical process equipment or to the decks' structure;
- possible injury/fatality of workers;

are classifiable as "Major Accident Hazard (MAH)".

The analysis of impact on the platform is based on crane characteristics, on location of critical equipment handling dangerous substances and on distribution of workers (considering that the platform is unmanned, and the presence of working personnel is limited to the maintenance activities).

3.1 Crane

The crane is located on the upper deck and can carry equipment or parts of these to/from the supply vessels. All the lifts to/from the supply vessel will be carried on the North-East side of the platform, where the crane is limited in its works. The location of the crane in the figure below is reported.

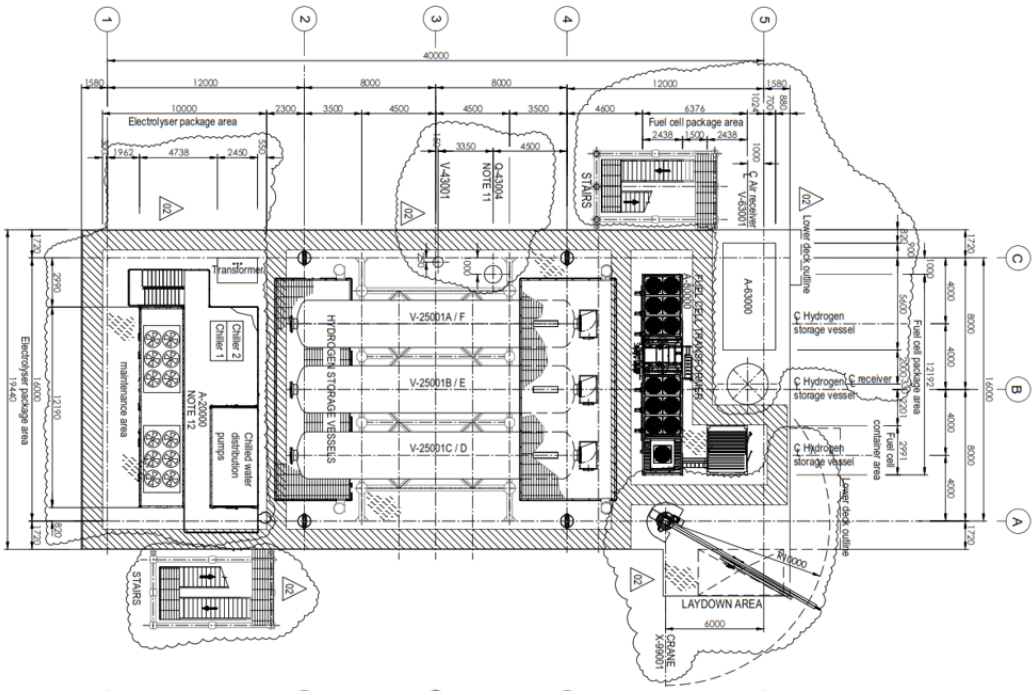


Figure 4 Upper deck – Location of crane

On the basis of current information, the needed of lifting object during maintenance should be performed only for some specific activities, meaning that the effective use of crane and loaded object will be very limited. At the present, the final design of the crane is not well defined. Anyway, from project specification, following main characteristics will be present:

- Maximum Load: about 1 ton at 10 meters
- Maximum height on the upper deck: 5 meters
- Crane working angle: about 130 °

In particular, in order to avoid impact on process vessel/deck structure, crane will be provided with limits switches to limit the crane working angle at about 130°. The working area of crane is reported in the figure below.

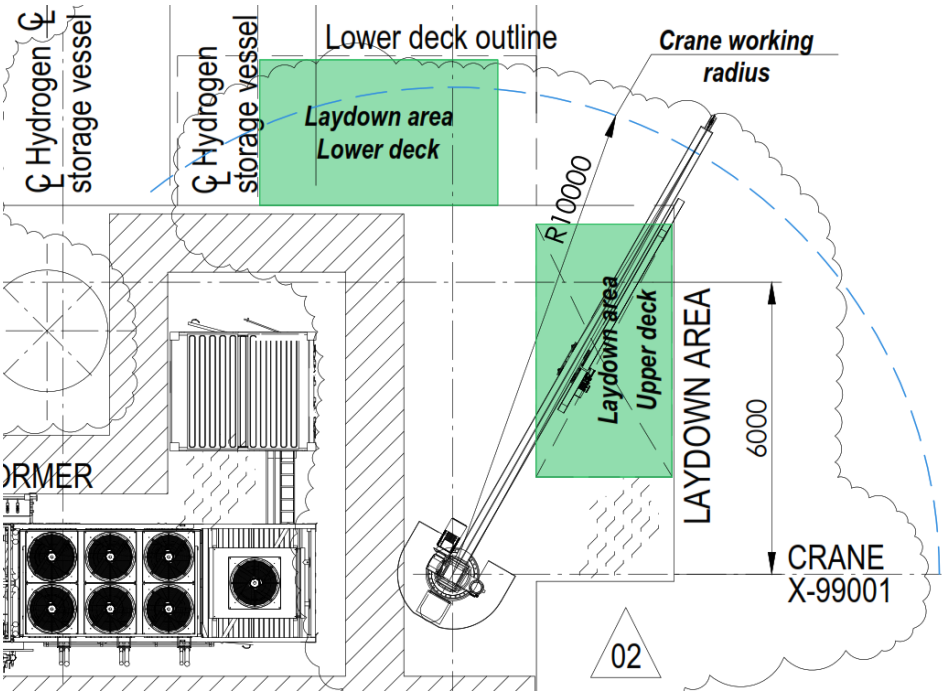


Figure 5 Detail of crane working area

3.2 Laydown area

The platform has 2 different laydown areas, located on the north and north -east sides where the crane can lift equipment from/to the supply vessel.

The loads to be lifted onto the platform can be laid on:

- upper deck, where the platform crane is located;
- lower deck, close to B-400 container.

As for document [6], the laydown areas was designed against a possible impact from 5 meters of a small container (weight about 3.5 tons) and a medium container (weight about 5 tons), which are higher that maximum capacity of the crane, which is limited to 1 ton.

3.3 MAH and acceptability criteria

In accordance with the scope of the present report, it is required to identify if a MAH that can be generated due dropped object.

MAHs are defined as [1]: *any unplanned and uncontrolled event that has the potential to lead to severe or catastrophic consequences to people, assets, the environment and/or business continuity and reputation*.

A MAHs is defined from at least one of the following categories:

- an incident involving an explosion, fire, or release of gas or dangerous substances with a significant potential to cause multiple fatalities;
- an incident leading to serious damage to the asset involving, or with a significant potential to cause, multiple fatalities;
- any other incident with a potential to lead to greater than 3 fatalities
- any major environmental incident resulting from incidents referred to in points above.

In accordance with HSE project design philosophy [1], risk acceptance criteria are defined by the colour scheme shown in the risk assessment matrix reported below.

SEVERITY	CONSEQUENCES				INCREASING LIKELIHOOD				
	People	Assets	Community	Environment	A	B	C	D	E
					Never heard of in the Industry	Heard of in the Industry	Has happened in the Organisation or more than once per year in the Industry	Has happened at the Location or more than once per year in the Organisation	Has happened more than once per year at the Location
0	No injury or health effect	No damage	No effect	No effect					
1	Slight injury or health effect	Slight damage	Slight effect	Slight effect					
2	Minor injury or health effect	Minor damage	Minor effect	Minor effect					
3	Major injury or health effect	Moderate damage	Moderate effect	Moderate effect					
4	PTD or up to 3 fatalities	Major damage	Major effect	Major effect					
5	More than 3 fatalities	Massive damage	Massive effect	Massive effect					

Figure 6 Project Risk Matrix

Where consequences have severity 5 or fall within the red area, the hazard are identified as Major Accident Hazards and require risks reduction measures.

Thus, for the evaluation of MAH due dropped object is required to evaluate if the impact of the falling object:

- for asset, determine a consequence with severity equals to 5 ("massive damage of platform") or a risk in the red zone of the matrix (from "moderate damage" to "major damage" with very high frequency of occurrence "D" and "E");
- for people, determine a consequence with severity equals to 5 ("more than 3 fatalities") or a risk in the red zone of the matrix (from "major injuries" up to "3 fatalities" with very high frequency of occurrence "D" and "E").

4 RESULTS

The consequence of dropped objects depends on the impact energy and the people, equipment and structures impacted by the objects dropped. For an object falling through air, the impact energy is calculated as the product of the mass of the object, the height and acceleration due to gravity.

Generally, people struck by falling objects can be assumed to be fatally injured, and objects striking hydrogen equipment will cause a hydrogen release. Damage to structures or other equipment struck by dropped objects may require a specific assessment of the resistance of the object impacted and/or the potential for a release from live equipment struck.

In the following chapters a qualitative analysis of consequences due falling object on asset and on people are summarized.

4.1 Decks' collision results

The two laydown areas are installed on north and north-east side of the platform (in which the crane can operate). The analysis is focused on following positions:

- Upper Deck: considering that the heigh of the crane from the deck is about 4 meters, it is possible to assume a maximum release height of about 3/3.5 meters (depending on the size of the object).
- Lower deck: considering that the elevation of the lower deck laydown from the top of the crane is about 7 meters, considering the size of the loaded object, the maximum length of falling from top of crane to the laydown area is assumed equal to 9/10 m.
- On the basis of crane working angle and the presence of limit switches, there is no possibility for the crane to move object above critical equipment or some structural parts of the deck. Thus, the impact of dropped object will be limited to laydown areas.

Regarding the expected consequences, the laydown areas are designed in order to withstand a possible impact of some reference dropped object with weight of 3.5 and 5.5 tons from 5 meters [6]. Considering that the design of the crane is limited to lift object with weight not greater than 1 ton, the expected damage will be limited, if any.

For the purpose of risk assessment, it is assumed that the dropping of the object is capable to determine localised structural damage to the laydown area. It is supposed the complete damage railings and partial damage of the grating of laid down area. Due to position of the lifting area, it is not expected the risk a severe process plant damage with need for plant shut down. On the basis of HAZID study [8], the maximum value in terms of consequences in case of dropped object on asset in assumed equal to "3", classified as "moderate damage". No impact to the mechanical integrity of the whole platform will be expected.

Regarding the frequency of occurrence, on the basis of frequency category of the risk assessment matrix, a object falling from the crane will be assumed equal to:

- "C, has happened in the organization or more than once per year in the industry";

At the present, no detailed information regarding expected crane utilization during maintenance activities are available. Anyway, considering that the platform is unmanned and the potential crane use are limited only due maintenance activities, the frequency category "C" can be considered applicable.

"C" as frequency category is also confirmed from dropped object on asset from Hazid study [8].

The application of the risk matrix, even if with conservative approach, identified following area, considering a severity of "3" and frequency between "C".

SEVERITY	CONSEQUENCES				INCREASING LIKELIHOOD				
	People	Assets	Community	Environment	A	B	C	D	E
					Never heard of in the Industry	Heard of in the Industry	Has happened in the Organisation or more than once per year in the Industry	Has happened at the Location or more than once per year in the Organisation	Has happened more than once per year at the Location
0	No injury or health effect	No damage	No effect	No effect					
1	Slight injury or health effect	Slight damage	Slight effect	Slight effect					
2	Minor injury or health effect	Minor damage	Minor effect	Minor effect					
3	Major injury or health effect	Moderate damage	Moderate effect	Moderate effect			Risk		
4	PTD or up to 3 fatalities	Major damage	Major effect	Major effect					
5	More than 3 fatalities	Massive damage	Massive effect	Massive effect					

Figure 7 Risk Matrix for asset – laydown platform

Additional potential consequences in terms of possible asset damage are connected with the damage of underwater power cable between the platform and the seaside and solar cable connecting to the floating solar panel. In the figure below, an extract from [7] is reported, showing the cables locations.

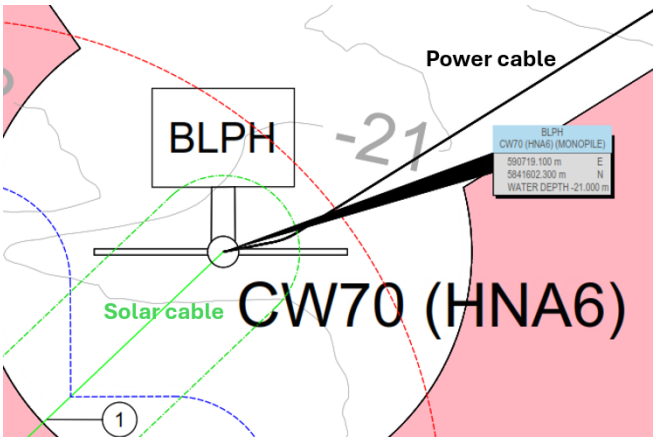


Figure 8 Extract showing cable location near platform

The power cable is located in the north-east side of the platform, in the working area of the crane; in the contrary, the solar cable is located in the south-west side of the platform, outside the working area of the platform. Thus, in order to evaluate possible consequences in case of dropped objects, only the power cable will be considered.

The power cable is buried and, considering the expected loaded equipment, a potential damage of the cable is considered very unlikely. For this case, the severity of consequences can be classified not more than "2"; in terms of frequency of occurrence, considering than the cable is below water and the cable diameter, which limiting the probability of a direct hit, a reducing factor for likelihood is selected compared to the laydown case, thus the frequency category "B" can be considered applicable.

SEVERITY	CONSEQUENCES				INCREASING LIKELIHOOD				
	People	Assets	Community	Environment	A	B	C	D	E
					Never heard of in the Industry	Heard of in the Industry	Has happened in the Organisation or more than once per year in the Industry	Has happened at the Location or more than once per year in the Organisation	Has happened more than once per year at the Location
0	No injury or health effect	No damage	No effect	No effect					
1	Slight injury or health effect	Slight damage	Slight effect	Slight effect					
2	Minor injury or health effect	Minor damage	Minor effect	Minor effect		Risk			
3	Major injury or health effect	Moderate damage	Moderate effect	Moderate effect					
4	PTD or up to 3 fatalities	Major damage	Major effect	Major effect					
5	More than 3 fatalities	Massive damage	Massive effect	Massive effect					

Figure 9 Risk Matrix for asset - power cable

For both the cases the resulting risk, obtained by the combination of the dropped object likelihood and the deduced consequence, can be classified in the tolerable risk region.

In conclusion, the risk of dropped object on asset are not classified as major accident.

4.2 Human-life risk results

During manned operations on the platform, it is expected the presence of workers near the loading/unloading areas, to pick up or release the loads. Anyway, operators are required to comply appropriate procedures during the material handling, in order to prevent accidents by falling objects.

For this reason, as well as considering the number of lifts, the drop frequency per lift and the probability to hit one of the loading/unloading areas, the human error probability shall be included in the identification of the frequency that determines the worker's injury/fatality.

In other words, it is assumed that the operators correctly follow the lifting procedure, and they are not standing onto the laid down areas (potentially target of the dropped object) during lifting operations.

In terms of risk calculation, this is assumed in reducing of one category of the frequency of the release from the crane already identified in chapter 4.1, meaning that the involvement of operator due dropped object is between:

- "B, heard of in the industry";
- "C, has happened in the organization or more than once per year in the industry".

At the present, no detailed information regarding expected crane utilization during maintenance activities are available. Anyway, considering that the platform is unmanned and the potential crane use are limited only due maintenance activities, the frequency category "B" can be considered conservative.

"B" as frequency category is also confirmed from dropped object on people from Hazid study [8].

In terms of consequences, the fall of the load, due to the relative weight and dimensions, most likely determines the fatality of the operator, in particular in case of dropping an object on the lower deck laydown area from the top of the crane (which is 10 meters heigh). For upper deck, it is unlikely the possible involvement of operators due the heigh of the load from the top of the crane (lower than 4 meters).

The severity for the consequence is assumed equal to.

- "4, PTD or up to 3 fatalities" (lower deck/upper deck);

"4" as consequences category is also confirmed from dropped object on people from Hazid study [8].

The application of the risk matrix, even if with very conservative approach, identified following area, considering a severity of "4" and a frequency of "B".

SEVERITY	CONSEQUENCES				INCREASING LIKELIHOOD				
	People	Assets	Community	Environment	A	B	C	D	E
					Never heard of in the Industry	Heard of in the Industry	Has happened in the Organisation or more than once per year in the Industry	Has happened at the Location or more than once per year in the Organisation	Has happened more than once per year at the Location
0	No injury or health effect	No damage	No effect	No effect					
1	Slight injury or health effect	Slight damage	Slight effect	Slight effect					
2	Minor injury or health effect	Minor damage	Minor effect	Minor effect					
3	Major injury or health effect	Moderate damage	Moderate effect	Moderate effect					
4	PTD or up to 3 fatalities	Major damage	Major effect	Major effect		Risk			
5	More than 3 fatalities	Massive damage	Massive effect	Massive effect					

Figure 10 Risk Matrix for operator

The resulting risk, obtained by the combination of the dropped object frequency and the deduced consequence, can be classified between tolerable and ALARP risk region.

In conclusion, the risk of dropped object on people are not classified as major accident.

5 CONCLUSIONS

The study has been developed to qualitatively assess the dropped object risk resulting from loading/unloading operations during maintenance operations on the platform.

The study is based on the evaluation of the risk against people and assets according to Risk Assessment Matrix.

Because of crane characteristic, the risk of dropped object is limited to the laydown areas on platform and to the power cables underwater. The qualitatively assessed risk for dropped objects is not a RAM 5 consequence or a red risk in the Risk Assessment Matrix. Therefore, this is not considered a MAH and a quantified approach to assess the risk of dropped objects is not required.

Indeed, both for asset and people, the severity of consequences is below the category "5" and the application of risk matrix does not identify risk in the intolerable region (red area).

In conclusion, the risk from dropped object on BLPH platform are not classified as Major Hazard event.

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